Critical Issues in Transportation

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As part of its mission to stimulate and disseminate transportation research, the Executive Committee of the Transportation Research Board periodically develops and publishes a list of critical issues in transportation. We do this in 1994 with the opportunities and challenges facing the transportation research community being as great as they have been for many decades. The shift in transportation goals represented by the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) challenges the transportation industry to incorporate an expanded set of disciplines and develop new research programs. The development of new technologies in areas such as information systems, advanced sensors, materials science, communications, and mathematical methods will help define a new vision for the transportation system for the 21st century, a system that must continue to provide for the appropriate, safe, and efficient mobility of people and freight. At the same time, increasing demands on the transportation system to support economic growth and competitiveness while operating in an environmentally sensitive and energy-efficient manner pose new challenges.

Only through a strong and aggressive research program can the nation use new technologies and concepts to meet these challenges. Additional funding for transportation research may result from defense conversion and technology initiatives at the federal level and from the private sector. Even so, some existing research resources may need to be redirected to respond to the challenges being faced. The Executive Committee's list of critical issues suggests areas for research investments; following through on these investments can pay the nation dividends well into the 21st century.

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In recent decades the U.S. economy and the demand on the transportation system have grown at a similar pace (Figure 1), and the demand for travel is expected to continue to grow. Current projections, for example, show industrial production and demand for freight transportation growing faster than the overall economy through the year 2000, yet the transportation system is not projected to expand to serve the growing demand. Meanwhile peak-period congestion on urban Interstates and other major arterials has grown substantially.

As a percentage of the gross national product (GNP), total public capital investment in transportation infrastructure has declined nearly 40 percent since 1960 (Figure 2). Investment in new facilities is not keeping pace with growth in demand, resulting in increased congestion. The less efficient movement of people and freight that results from congestion raises concerns that the economy will suffer losses in productivity, resulting in slower economic growth.

Although spending on highways has

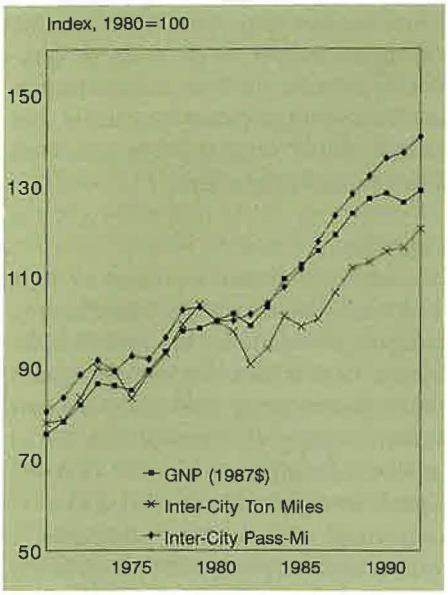

FIGURE 1 National transportation and economic trends (*1*).

recovered from the low reached in the early 1980s, real public capital investment in transportation infrastructure is hardly more than it was two decades ago (Figure 3). (The apparent steep decline in highway spending shown in Figure 3 reflects a period of high inflation and hence reduced purchasing power in constant dollar terms.) On a per capita basis, transportation spending has recovered from the low reached in 1980 but remains below the peak of 1965. The decreased rate of transportation investment as a fraction of the economy is not simply a matter of having a smaller share of resources, although that is certainly a major reason. It is also due to increased public demand—and legal requirements—for clean air and water and for less noise intrusion on residences and neighborhoods. Community resistance to new facilities and regulations to protect the environment have made it more expensive and difficult to expand highway capacity, site or expand airports, build transit maintenance garages, upgrade rail facilities, and dredge harbors and channels serving the nation's ports.

On the basis of trends in travel demand and public support for environmental regulation, it appears that Americans desire a quality of life that includes both a high level of mobility and a clean environment. How can the transportation system deliver the goods and provide the mobility that is so important to prosperity and at the same time minimize negative environmental effects? Determining the implications of the trade-offs among the goals of mobility, economic growth, and environmental protection, and finding ways to minimize the conflicts among them, has become an overarching concern for the transportation sector in the 1990s. This concern is confronted most directly in the first critical issue discussed here (sustainable transportation), but it will undoubtedly shape the context for how other critical issues are defined and addressed.

The TRB Executive Committee regularly outlines critical issues in transportation. Critical issues are defined as important, unresolved aspects of transportation that are national in scope, on which there are a wide variety of viewpoints, for which the impacts of possible actions are uncertain, and for which decisions will be

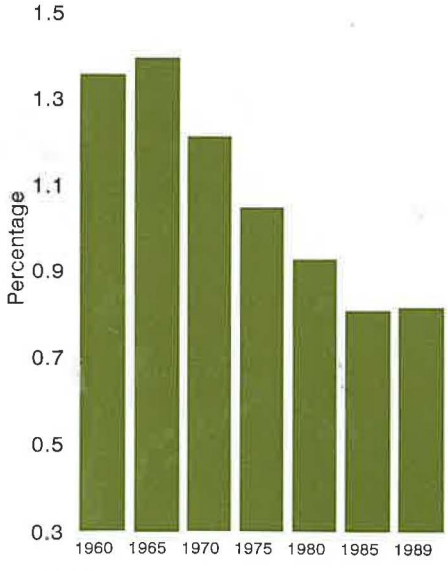

FIGURE 2 Public sector capital spending on transportation as a percentage of GNP (2).

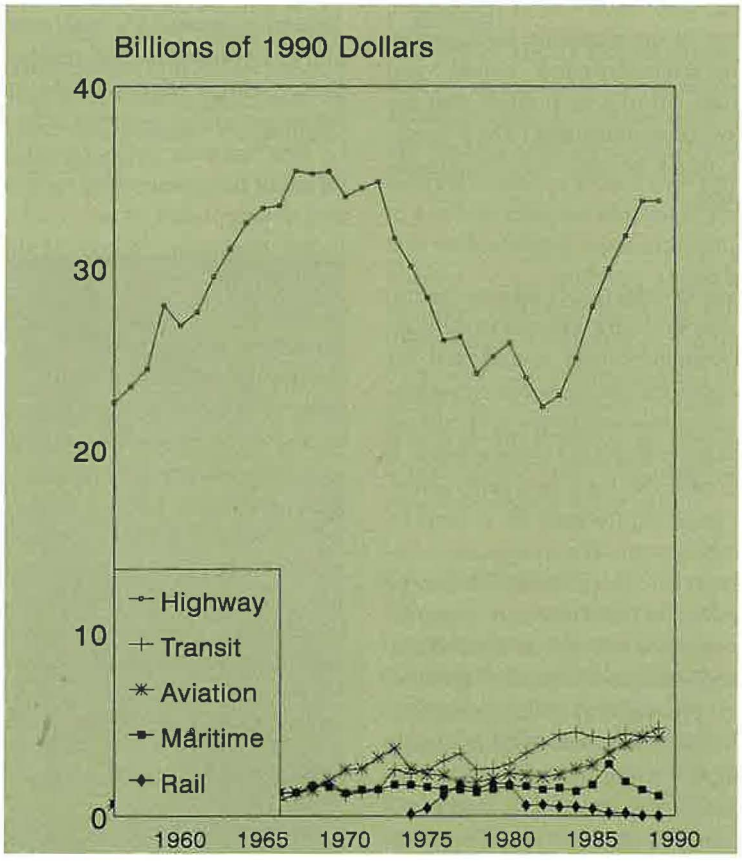

FIGURE 3 Public sector transportation capital expenditures, 1956–1989 (2).

made at the policy level. Current critical issues identified by the Executive Committee are the following:

- Sustainable transportation,
- Institutional and legal reform,
- Technology,
- System management,
- Safety,
- Intermodal issues,
- International issues,
- Quality,
- Human resources, and
- Finance.

Sustainable Transportation

The concept of sustainable development is now receiving worldwide attention. It encompasses both a mandate to stop irreversible damage to the ecosystem and recognition that the pursuit of environmental goals must accommodate the human needs of the planet's burgeoning population, both now and in the future. The concept of sustainability ties together economic, environmental, social, and energy goals, all of which affect and are affected by transportation. Thus transportation must be part of sustainable development.

Concerns

The interest in sustainable transportation reflects the growing recognition that, although transportation is essential for economic growth, the resource consumption and environmental impacts of current transportation policies are incompatible, if continued into the long run, with scientific and popular notions of a healthy world environment. Transportation consumes almost one-third of all U.S. energy use annually. Its consumption of petroleum accounts for two-thirds of domestic demand and continues to grow (Figure 4). Petroleum consumption in the transportation sector alone exceeds total domestic petroleum production. Transportation contributes nearly one-third of annual emissions of carbon dioxide resulting from human activity and is a major source of emissions regulated by the Clean Air Act (Figure 5). It is hard to imagine that sustainable development could be achieved without a "sustainable" transportation system.

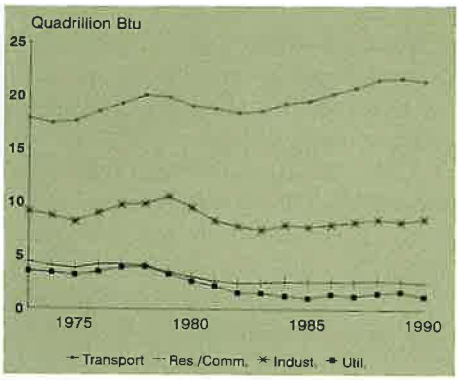

FIGURE 4 Consumption of petroleum by end use sector (3).

Key Questions

Precisely what a sustainable transportation system means is debatable, but certainly a major transportation issue facing the world community is how to achieve a balance between mobility and access needs (which strongly affect economic development and life-style) on one hand and environmental and resource imperatives (which affect human health and future economic potential) on the other.

The research issues raised range from issues of basic science to applied research and development of new technologies to policy evaluation. What are the essential ways in which transportation contributes to economic vitality? What is the contribution of transportation to irreversible environmental loss? What combination of policies could alter the demand for travel in the most cost-effective way? Which new technologies appear most promising for providing mobility at minimal cost and inconvenience to users, and how can they most effectively be brought to the marketplace by public policy? (TRB is just beginning a policy study that will attempt to frame and address these questions.)

Institutional and Legal Reform

Institutional, intergovernmental, and legal issues are close to the heart of many transportation problems. Proposed remedies for these problems have often proven elusive because of decentralized decision making across levels of government; complex, sometimes conflicting, responsibilities of different governmental units; and the difficulty of merging public goals with those of the private sector.

Concerns

Although institutional reform as a means of rationalizing and better coordinating transportation policies has been a high-priority item within the transportation community for many years, there is a new sense of urgency. For example, the Clean Air Act Amendments of 1990 (CAAA) require metropolitan areas that are out of compliance with clean air standards to develop specific plans and timetables for meeting federal requirements. ISTEA places renewed emphasis on metropolitan planning organizations (MPOs) in weighing the priorities in regional transportation capital plans and ensuring that they

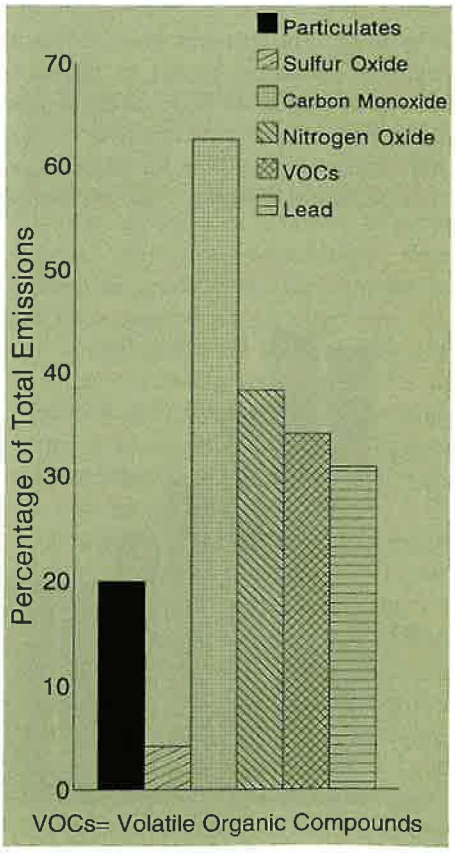

FIGURE 5 Transportation's contribution to emissions regulated by the Clean Air Act (3).

are in compliance with CAAA. The urgency about institutional issues also arises from the growing recognition that technologies designed to reduce congestion [such as intelligent vehicle-highway systems (IVHS)] and management and pricing strategies (such as congestion pricing) would require institutional reform. Such reform may include not only changes to responsibilities among governmental units but also the establishment of new agencies or special authorities and new public-private partnerships in the operation of transportation systems. In aviation, a proposal to change the Federal Aviation Administration (FAA) from a government agency to a publicly owned corporation is being proposed by President Clinton's administration as it seeks to "reinvent" the agency.

Institutional cooperation and reform at the regional level are greatly complicated, however, by the different jurisdictions in each metropolitan region and by the conflicting priorities they pursue. Regional efforts to meet CAAA planning requirements have foundered in some cases because of the different economic development priorities of individual jurisdictions. MPOs often represent fragile coalitions of local interests and have little power to leverage compromises. Moreover, private sector users of the system are not always represented. Planning for urban passenger travel, for example, tends to take priority over concerns about goods movement. Advancement of IVHS technologies could be hampered by cross-jurisdictional conflict, and legal concerns about assumption of liability in public-private ventures are an additional complication.

Key Questions

What institutional reforms at the regional level would better allow local jurisdictions to reach agreement on environmental and transportation goals? What kinds of new or expanded use of existing institutions would permit new technologies and policies such as IVHS and congestion pricing to advance? How can goods movement issues be represented in public decision making at the local and regional level? How can private sector concerns about the assumption of liability in public-private partnerships be addressed while safeguarding public safety? How can FAA be reorganized into an entity that has the incentives for service and cost control of the private sector yet retains its commitment to public safety?

SCIENCE APPLICATIONS INTERNATIONAL CORP./TRAVTEC

New technologies, such as "smart cars," illustrate new opportunities and challenges for the innovation process from research through deployment.

Technology

The transportation industry will continue to look to technology as one important response to the problems posed by growth and by the challenge to develop sustainable transportation systems. Promising opportunities include the application of advanced computer and information technologies to logistics, traffic management (air, highway, and rail), and public transportation; development of more fuel-efficient, environmentally benign automobiles; wider use of lightweight composite materials; use of the technologies and technological capabilities developed by defense industries; and substitution of communication for transportation through such developments as the "information superhighway." To seize these opportunities, a variety of issues must be confronted about how to best encourage, manage, and finance the innovation process from research through deployment.

Concerns

The public sector side of the transportation system is mature and tends to resist adoption of new technologies. Although the current emphasis on defense conversion represents a major new opportunity to explore and develop new transportation technologies, memories linger of the failures (e.g., applying aerospace technologies to urban travel in the 1970s). Regarding the replacement of transportation with communications, new computer and information technologies and potential applications are emerging at a dizzying rate, but their implications for travel are highly uncertain.

Key Questions

How can the decentralized transportation sector best organize itself to test, evaluate, disseminate, and adopt promising new technologies at a faster rate? Are the major barriers to innovation legal and regulatory? Do the problems stem from inadequate funding of research and development? How can an institutional culture that resists change become more adept at encouraging and applying innovation? What are the most promising applications

of information technology that would reduce or replace travel?

System Management

Increasing the efficiency of the existing transportation infrastructure will continue to be a critical issue facing virtually all modes for the foreseeable future. Productivity gains are badly needed for both operations and maintenance. In some cases managing transportation systems to achieve improved performance could be facilitated by new technologies, institutions, and philosophies about service delivery and efficiency. In others, gains could be made by using the best current technologies and practices on a more systematic or widespread basis (e.g., making decisions based on life-cycle costs).

Concerns

ISTEA requires states and metropolitan areas to develop management systems for congestion, pavements, bridges, safety, intermodal activities, and public transportation. Although pavement and bridge management systems have been in development for some time, development of systems in the other areas will require extensive analysis, data collection, and cross-jurisdictional cooperation.

Key Questions

What changes are of highest priority in building toward a system management approach? Are they in technology, behavioral change through demand management, or institutional reforms? Good management systems require good data, but considerable work needs to be done to define the data needs for intermodal system management, and then substantial effort will be required to assemble the information.

Safety

Although the number of deaths caused by transportation accidents has declined during the past 20 years as a variety of safety measures have been adopted, the total is still unacceptably high. Roughly 45,000 people have died in transportation accidents in the United States each year during recent years; almost all of these deaths occur to motor vehicle passengers or pedestrians (Figure 6). The total number of deaths provides only part of the picture. Nearly 3.5 million people are injured each year in transportation; the majority of these injuries occur in highway transportation (5). Although most are minor or moderate, nearly 475,000 motor vehicle injuries are severe or fatal. Improving transportation safety is a public health issue of the highest concern. Progress is being made. The number of highway fatalities dipped below 40,000 in 1992, and the fatality rate per 100 million vehicle miles continues to fall (Figure 7). Continued reductions in fatalities, however, may abate unless new safety measures are developed and applied.

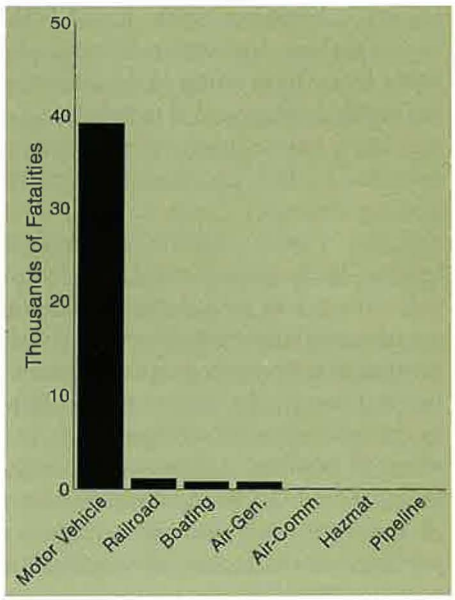

FIGURE 6 Fatalities by transport mode (4).

Concerns

The most obvious, cost-effective improvements to transportation vehicles and control systems, regulations, and behavior have been identified, and many have been introduced. The identification of further improvements will require creativity, innovation, and better understanding of the factors that contribute to accidents and affect their consequences. Moreover, there will be new safety issues to consider as new technologies are introduced (such as advanced air traffic control technologies), the transportation of hazardous materials in populated areas continues to grow, and transportation workers are exposed to new materials and pressed to maintain facilities while they remain in service. The shortage of experienced truck drivers raises concerns that the newer, less experienced operators will pose a higher risk unless they are adequately trained and prepared. In addition, traffic police from around the nation express concern about erosion of compliance with speed limits and other traffic regulations in both urban and rural areas.

Key Questions

Where are the greatest risks to the public in the current transportation system, and how can they be reduced in the most cost-effective manner? The answers to these questions are hampered by lack of consistent measures of risk across modes and inadequate data, yet they are of great importance. Other important questions include, How much emphasis should be placed on technological improvement as opposed to behavioral change? What gains could be expected from the next generation of occupant protection standards? Which safety programs appear to be effective? How can continued progress be made with perennial problems such as driving under the influence of alcohol and other drugs? What are the risks of reduced traffic law compliance, and how

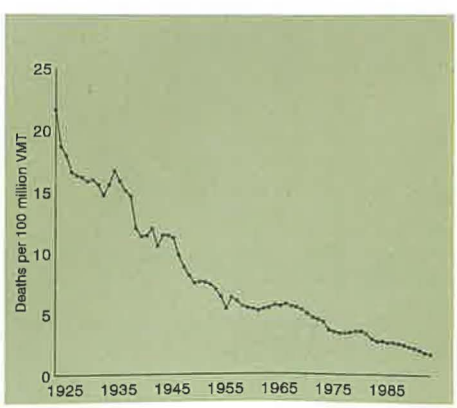

FIGURE 7 Motor vehicle deaths per 100 million vehicle miles traveled (VMT) (6)

can this problem be best addressed? What incentives will encourage more use of safer modes of travel? As new technologies are introduced, will concerns about driver information overload have been adequately addressed?

Intermodal Issues

The National Transportation System planning process to take place during the next two years as announced by Secretary of Transportation Federico Peña has placed renewed emphasis on intermodalism. The search for more efficient and sustainable transportation systems must include planning and management strategies that cross modal boundaries. Indeed, ISTEA explicitly recognized the need to develop networks and services that include multiple modes working cooperatively. "Seamless" services that take advantage of the strengths of different modes and minimize the disruptions of intermodal transfers are already being used in freight transportation (e.g., intermodal marine container service) and provide a model that could be expanded to passenger transportation (e.g., integrated air and high-speed rail service). Intermodal approaches to transportation are, however, complicated and difficult to organize.

Concerns

Some of the barriers associated with intermodal transportation include single-mode orientation in existing transportation organizations; inconsistent and incompatible measures of performance across modes; requirements for new public-private working relationships; funding that is derived from and tied to specific modes; and inconsistent regulatory approaches across modes. These concerns are compounded by competition among the modes (in the public and private sector), which poses a challenge to increasing cooperation.

Key Questions

How can the institutional barriers that inhibit greater modal cooperation be reduced? How can the benefits of modal competition (e.g., cost control) be maintained while simultaneously improving modal cooperation? Should existing modal trust funds be combined into transportation trust funds? Is there a sufficient lack of a "level playing field" in federal and state policies for modal competition to justify subsidies or reduced regulation? What are the important system characteristics and data requirements of an intermodal management system?

International Issues

U.S. transportation is increasingly affected by economic and political changes outside the United States. The globalization of industry and new trade agreements are changing the level and pattern of freight traffic. Political changes in Eastern Europe

PORT OF TACOMA

Intermodalism in freight transportation relies on cooperation among several modes.

and the former Soviet Union are compounding these changes and may introduce new services to the world's transportation network (e.g., Pacific to Europe rail service across Russia). Regulatory changes overseas will change the competitive posture of U.S. international carriers and create pressures for "harmonization" of U.S. safety and performance regulations with trading partners. In addition, there are transport technologies that have been developed or refined abroad that should be tried in the United States.

Concerns

International concerns can be grouped into three broad categories: (*a*) the impact on the domestic transportation system, (*b*) the impact on U.S. carriers, and (*c*) technology transfer. Trade liberalization through the General Agreement on Trade and Tariffs and the North American Free Trade Agreement could have a significant impact on domestic transportation facilities. The nation needs adequate airports, ports, and border crossings to handle increased trade. Decisions about improving most facilities, however, are made at the local or state level, which raises concerns about whether these decisions adequately reflect the national interest. However, because they lack specific statements of long-term national interest, it is difficult for state-managed systems to reflect national interests.

As the pressures of world competition mount, nations around the world are increasingly using transportation policies to foster or protect domestic industries. Foreign regulations governing the use of major international airports, subsidies to domestic carriers, and other policies directly affect the ability of U.S. carriers to compete in other nations. The importance and effect of these policies on U.S. carriers are not widely understood. Other nations, in contrast, appear to have a clear understanding of how to access and use the U.S. system to their advantage.

During the post–World War II era, the United States was considered the major innovator in transportation facility design and construction. Recent tours of contracting and design practices in Europe, however, have revealed that the United States has much to learn from other industrialized nations. There is a growing awareness within the transportation sector that the United States is no longer simply an "exporter" of technology and innovation and that the nation is ill-prepared to "import" new developments.

Key Questions

How can the United States best anticipate, adapt to, and capitalize on the opportunities presented by international developments? How well is the national interest reflected in infrastructure investments that support international trade? What international developments could have the most far-reaching consequences for U.S. firms and domestic transportation? Which modes or sectors would be most affected and how? What is the institutional capability of private industry, government, universities, and associations for staying abreast of transportation-related research and development outside of the United States, particularly in non-English-speaking nations? What successful strategies have other nations developed to "import" new practices and technologies and to stay aware of the policies of other nations?

Quality

Many transportation agencies, particularly in the public sector, believe that much more can be done to improve the quality and performance of the nation's transportation infrastructure without introducing new technologies. In part, building in greater quality requires better technology transfer processes, additional training for transportation personnel, and new attitudes throughout the industry. It may also require a better balance between minimizing life-cycle costs and initial project costs.

Concerns

Private firms in the United States are increasingly focusing their institutional cultures on providing quality customer service. Public agencies find such a customer-focused orientation more difficult to achieve because of the many objectives that they must meet. Most public agencies also lack the incentive to focus on quality because they do not have to face the intense competition that exists in the private sector, where the lack of quality service can directly result in lost customers, income, and jobs. The elected officials who appoint public agency executives, of course, have to face the voters, which does give an impetus for a customer focus.

Provision of higher quality products in transportation may require finding a coexistence between low-bid procurement and full life-cycle costing. Political and administrative incentives that place more emphasis on short-term improvements than the efficiency of long-term performance make such a change difficult. Moreover, this shift may not be possible without significant reforms to current design and contracting practices such as the expanded use of performance specifications and the introduction of greater contractor responsibility for construction quality.

Key Questions

How can public agencies be continually renewed to provide the public with quality service at minimal cost? What incentives can be developed and offered to employees and employers to reward striving for quality? What are the initial capital costs and maintenance costs of alternative technologies? Which technologies provide the greatest value? How can procurement processes and project financing be reformed to provide the public with a better quality, more efficient system?

Human Resources

Some transportation organizations already face shortages of skilled personnel, and these shortages may worsen in the future for several reasons. Senior professionals in many public agencies are reaching retirement age, and these agencies are often under pressure to limit new hires. The number of graduates of key technical programs has declined, and many transportation agencies offer below-average salaries to entry-level professionals. Finally, as all modes of travel become more complex

SUPERSTOCK

Future professionals in transportation will come from diverse fields and backgrounds.

technologically, work force requirements are increasingly sophisticated, and mismatches between employee skills and employer needs are more likely. Addressing this issue may require greater reliance on contracting for services by public agencies, reforms in job classifications and salary scales, and more aggressive in-house training programs.

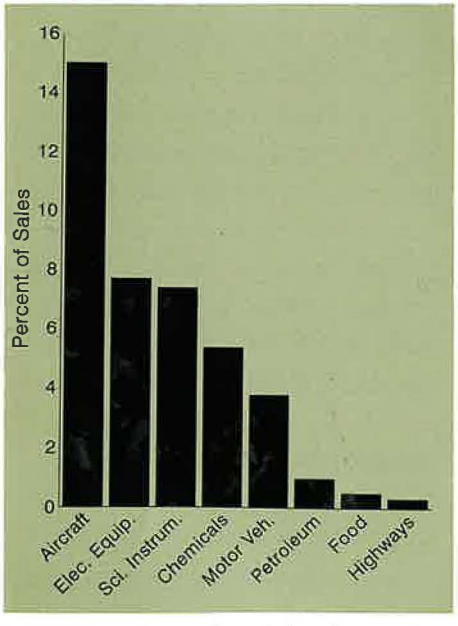

FIGURE 8 Research and development in selected industries compared with highways [National Science Foundation (7) and TRB estimates].

Concerns

Transportation workers in the future will need to be better educated to operate increasingly complex technologies. The transportation professional of the future will need to be better trained and more aware of technological, institutional, environmental, and societal issues and policies. Many state and federal transportation agencies are beginning to feel the effect of the retirement of their most senior workers, particularly engineers. Even for those that do have replacement personnel available, entry-level employees will be harder to find. The number of students graduating from the civil engineering programs that have supplied transportation agencies and firms in the past has declined, and fewer students are pursuing advanced degrees. This creates an opportunity to recruit students with backgrounds in other disciplines, but greater effort may be required to interest these students in transportation careers. Public agencies also need to recruit more aggressively among women and minorities to increase their opportunities in transportation. Agencies will have to develop and support education and training programs to prepare their work force and will probably have to struggle to keep salaries competitive with the private sector.

Key Questions

As transportation agencies shift emphasis toward system management and rely more heavily on technology, their personnel needs will change. Some state and federal agencies, however, are finding that rigid job classifications and pay levels are impeding their ability to find the best people for the job. Can civil service systems be reformed to provide more flexibility? What kinds of training programs will be needed to prepare a less skilled work force for technical jobs? How can the diversity of transportation professionals be expanded to be more representative of the American population? Better marketing of transportation industry careers would help recruiting. How can the various transportation professional associations fill this role? How much can technology reduce the reliance on personnel (e.g., through computer-aided design and other productivity-enhancing technologies)? Which segments of the work can be effectively and more efficiently provided by private suppliers?

Finance

New investment in transportation infrastructure in the United States continues to decline as a percentage of GNP, and research spending, related to highway transportation infrastructure, is well below the levels of research and development investment, even by "low-tech" private sector industries (Figure 8). Nevertheless, as the nation moves toward a goal of sustainable transportation, costs for both construction and operation of transportation facilities will probably increase, as evidenced by the costs of environmental mitigation measures on urban highways and the costs of operating public transportation services in low-density areas to provide an alternative to automobile travel. Such increased demands for funds will place greater demands on the highway user charges that are also needed for upkeep of the extensive network that has been built during the last few decades.

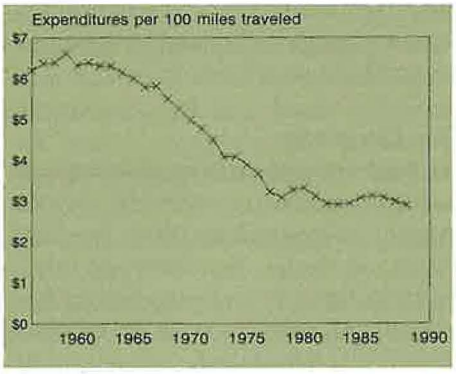

FIGURE 9 Public sector expenditures (in 1990 $) per 100 miles traveled (2,4).

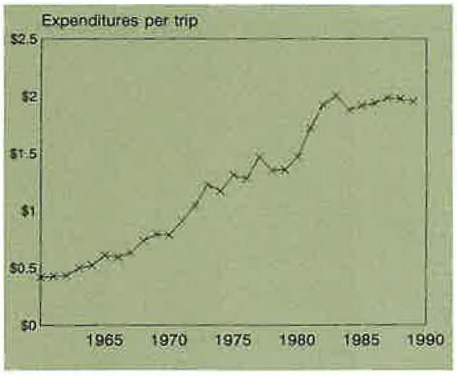

FIGURE 10 Public sector expenditures (in 1990 $) on transit per unlinked passenger trip (2,8).

Concerns

Although total expenditures on highways (in real terms) have reversed the sharp declines experienced in the early 1980s, total demand for travel, especially personal automobile transportation, has grown more rapidly. As a result, total public expenses on highways per mile traveled continues to decline (Figure 9). Some of the decline reflected in Figure 9 is a result of reduced investment needs following the completion of the Interstate system, but with many of the highways and structures built more than 20 years ago reaching the end of their expected service lives, expenses for ongoing major repair, rehabilitation, and replacement cannot be avoided.

Total trips on transit, however, have not increased appreciably since 1960, thus expenditures per trip have increased (Figure 10). Total spending for public transportation, both capital and operating, has increased in real terms during the last three decades in order to upgrade systems that had been neglected in previous years and to provide better service. Federal operating assistance has remained fairly constant in current dollars during the last decade, but the cost of operating systems has grown. Revenues from users have increased somewhat, but not enough to cover operating costs. Thus transit agencies have increasingly needed operating assistance from state and local governments to cover total operating budgets. Operating assistance from states has grown to exceed that of the federal government. Improving transit productivity requires, among other things, reducing some of the hidden subsidies that encourage automobile use. Such hidden subsidies include use of property taxes to pay highway operating expenses, employer-provided free parking, and a more generous tax-exempt status for parking privileges than for transit passes.

Key Questions

The trends shown in Figures 9 and 10 do not specify the appropriate level of expenditures on highways or transit systems. Capital investments occur in large lumps that then have long service lives. Determining the appropriate level of capital needs, the appropriate mix between new capital and maintenance spending, and an appropriate level of funding for operations are vital issues for research.

The rationale of a user-financed system, in which the users could be assured that their taxes would be dedicated to the system, has been weakened by the shifting of user taxes to cover general fund deficits. In an era of tight public resources and voter resistance to tax increases, how can the transportation community better explain to elected officials the benefits of transportation investments and research? What innovative and flexible funding strategies have promise to provide adequate funds for maintaining the system?

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